Effects of surface BRDF on OMI cloud and NO_2 retrievals

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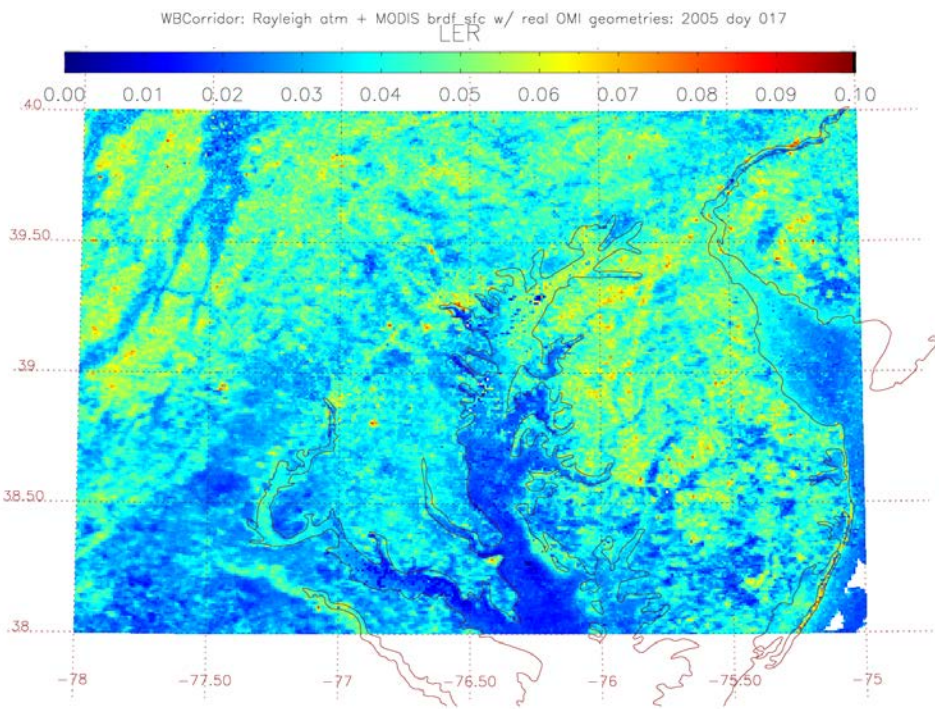
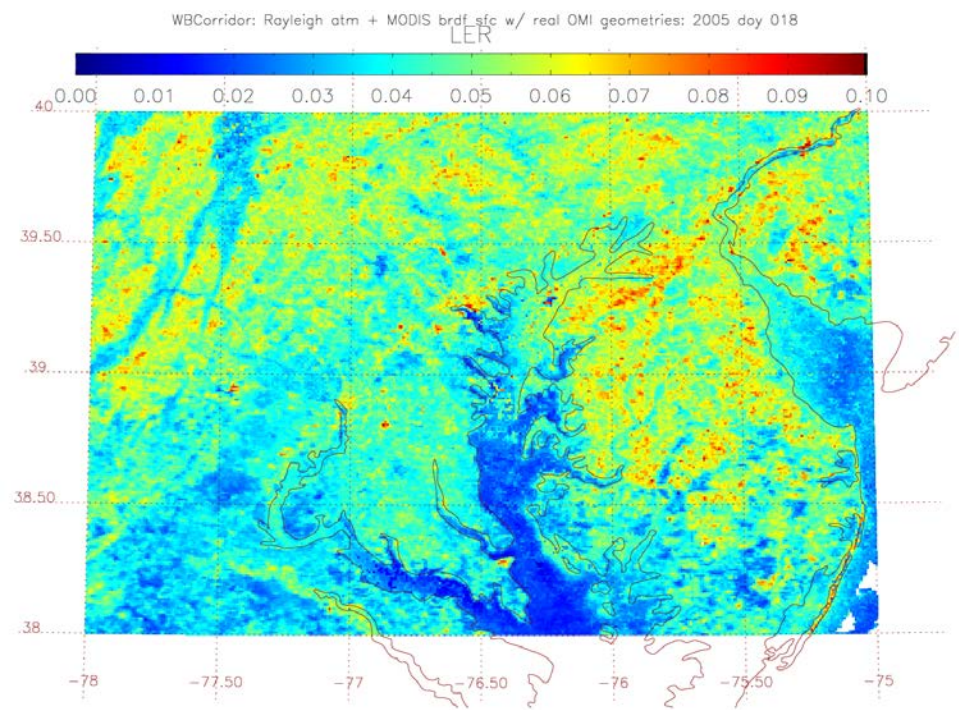
Motivation

- Light reflection from surface significantly affects cloud and trace-gas retrievals.
- Reflection of incoming light does depend on the observational geometry described by the Bidirectional Reflectance Distribution Function (BRDF)

BRDF: same area, two consecutive days





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The Washington-Baltimore area: high-resolution LER computed from MODIS-derived BRDF for OMI geometries

Geometry-dependent Lambert-Equivalent Reflectivity (GLER) approach

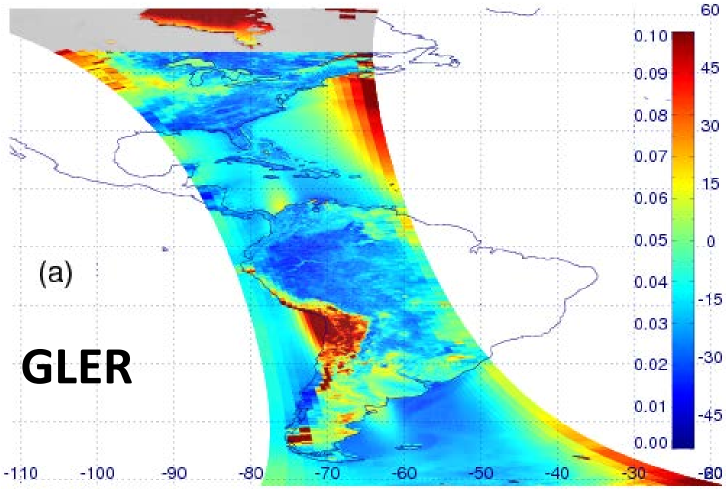
- Details are given in W.Qin's talk.
  - GLER is derived from TOA radiance computed with Rayleigh scattering and BRDF for exact satellite geometry
  - MODIS BRDF over land; Models over the ocean
- No major changes to existing trace gas and cloud algorithms
  - A simple replacement of the existing static LER climatology (no dependence on sun-view geometry) with GLERs is needed.
- We generated an orbit-based, global GLER product for OMI. A similar product can be generated for any current and future satellite instrument.

Evaluation of the GLER approach

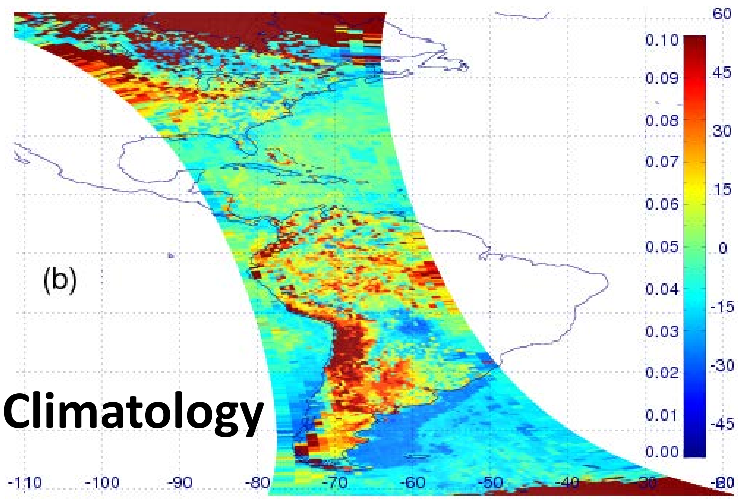
- We applied the GLER approach to OMI cloud and NO_2 algorithms.
  - Cloud algorithms based on Rotational Raman Scattering (RRS) in UV (354 nm) & O_2-O_2 absorption in Vis (477 nm)
  - Cloud products: effective cloud fraction (ECF) and effective cloud pressure or optical centroid pressure (OCP)
- The cloud and NO_2 retrievals based on the GLER are compared with those based on the climatological LERs from TOMS and OMI.
- The resulting differences include both BRDF effects and possible biases between the MODIS and other instrument reflectance data sets.

Comparison of GLER with climatological LER (470 nm)

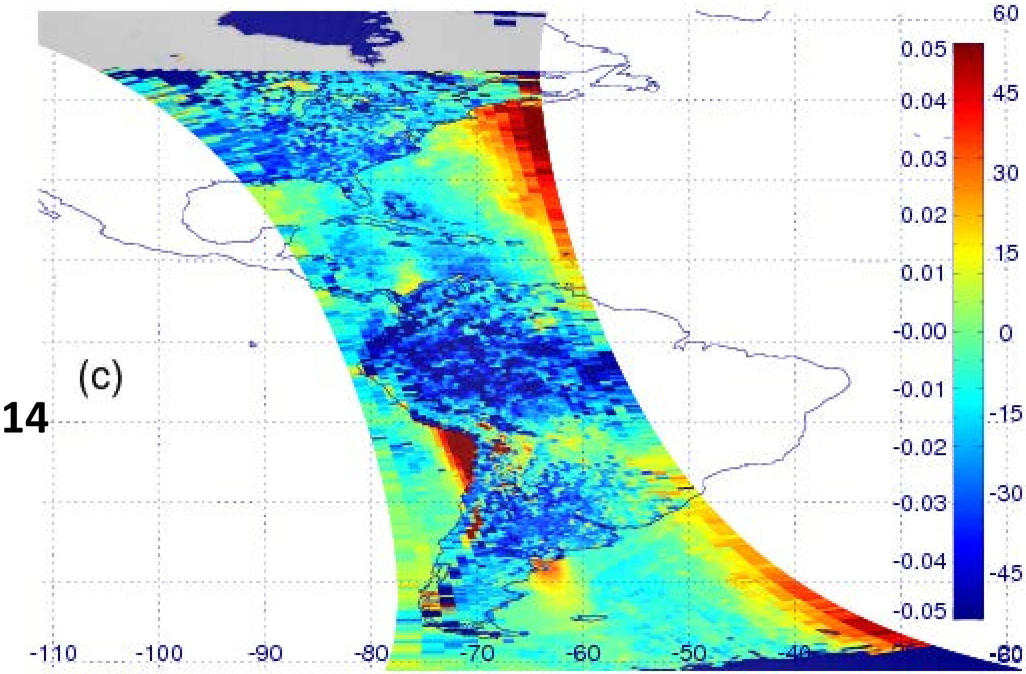
No BRDF data for lat > 50^0



Orbit 12414



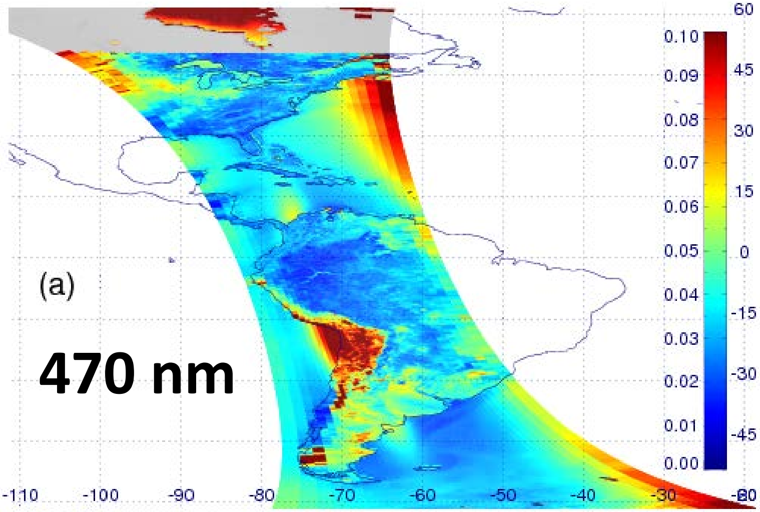
LER difference (GLER – climatology)

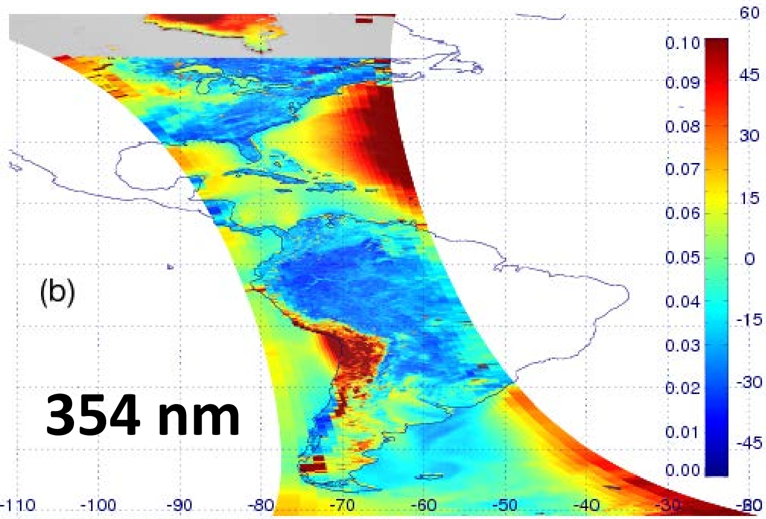


Negative differences mostly over land (up to 0.05 over Amazonia - cloud contamination of the climatology)

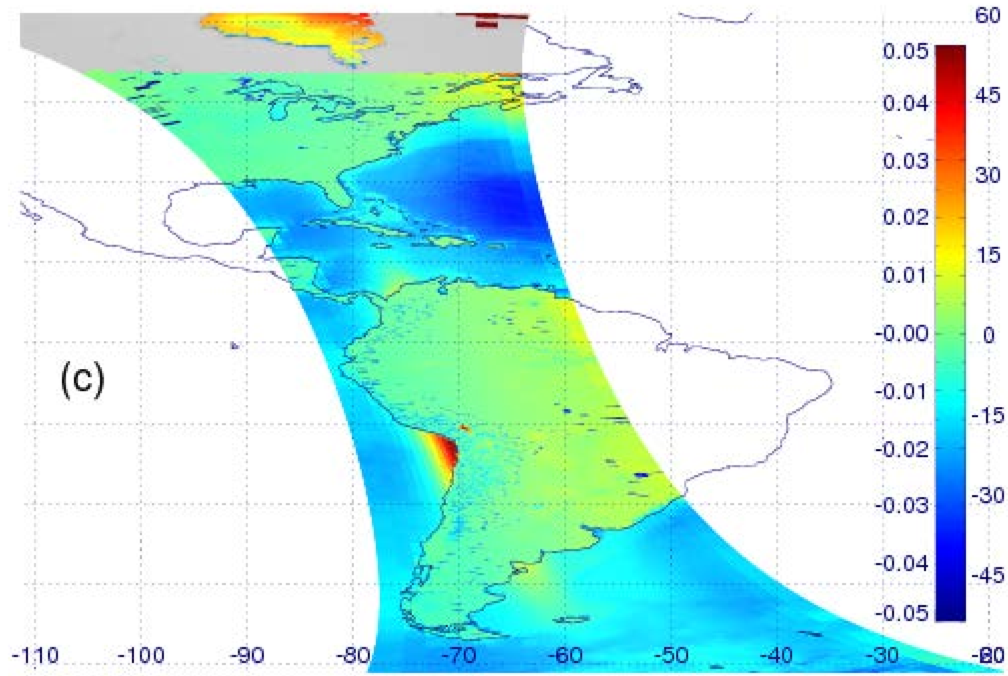
Positive differences mostly over ocean (sun glint and large VZA areas)

Comparison of GLERs in UV and Vis





GLER difference (470 nm – 354 nm)



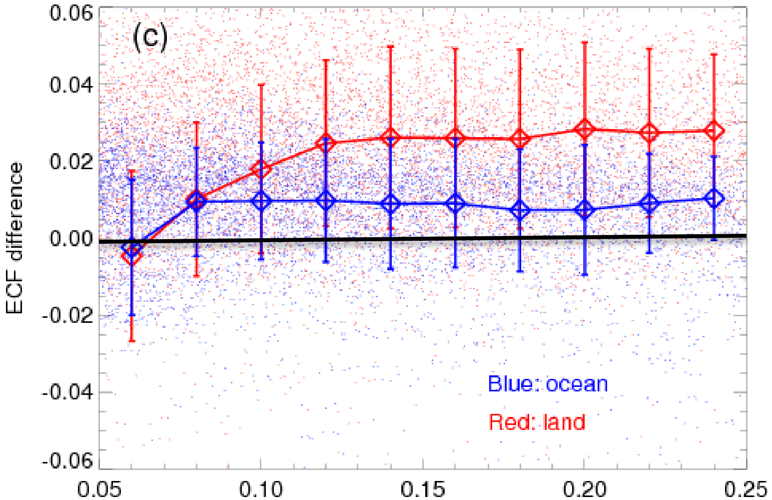
Generally, BRDF effects in UV are lower than that in Vis because of smoothing the effects caused by higher Rayleigh scattering in UV (land and sunglint).

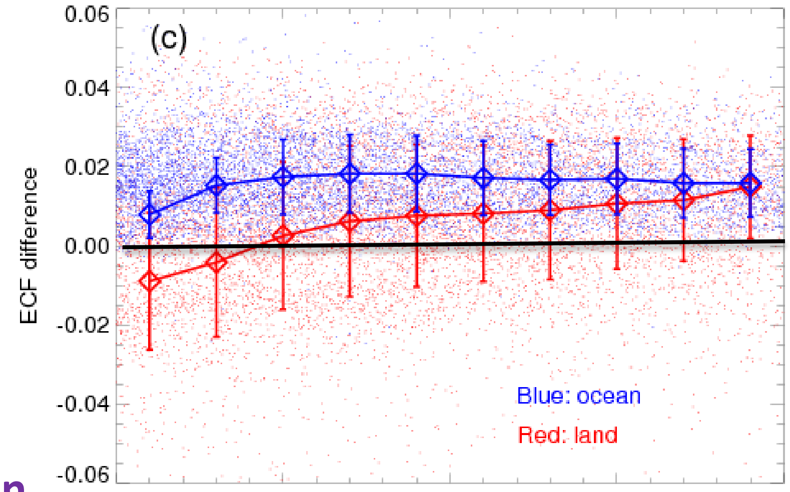
Over ocean, GLER at 354 nm is higher than that at 470 nm due to greater water-leaving radiance at 354 nm.

Comparison of the ECF and OCP differences from O_2-O_2 and RRS

O_2-O_2

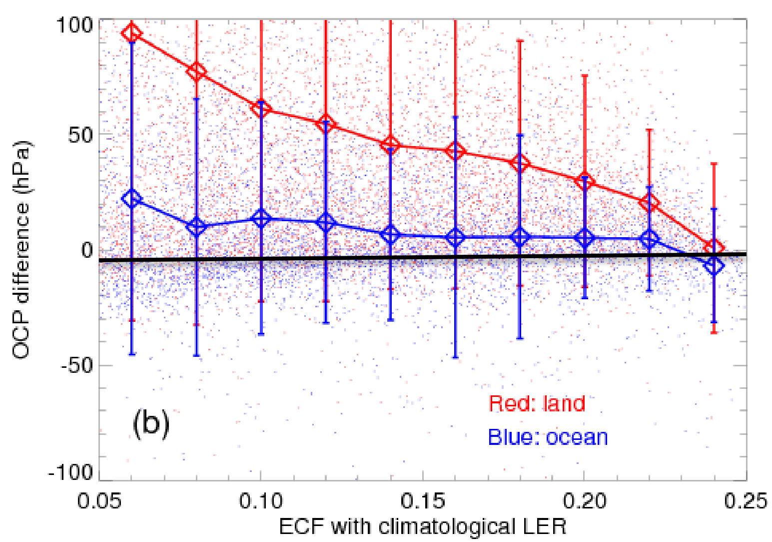
RRS

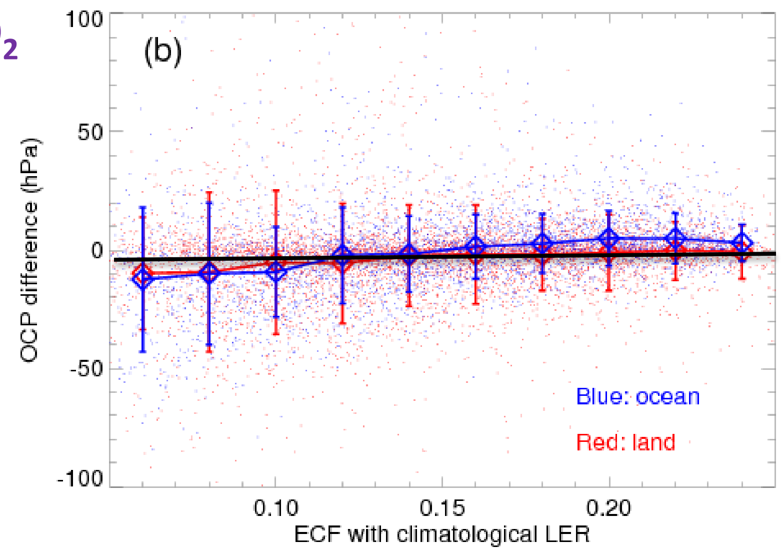




Standard deviations of ECF difference are larger for O_2-O_2 than for RRS.

ECF



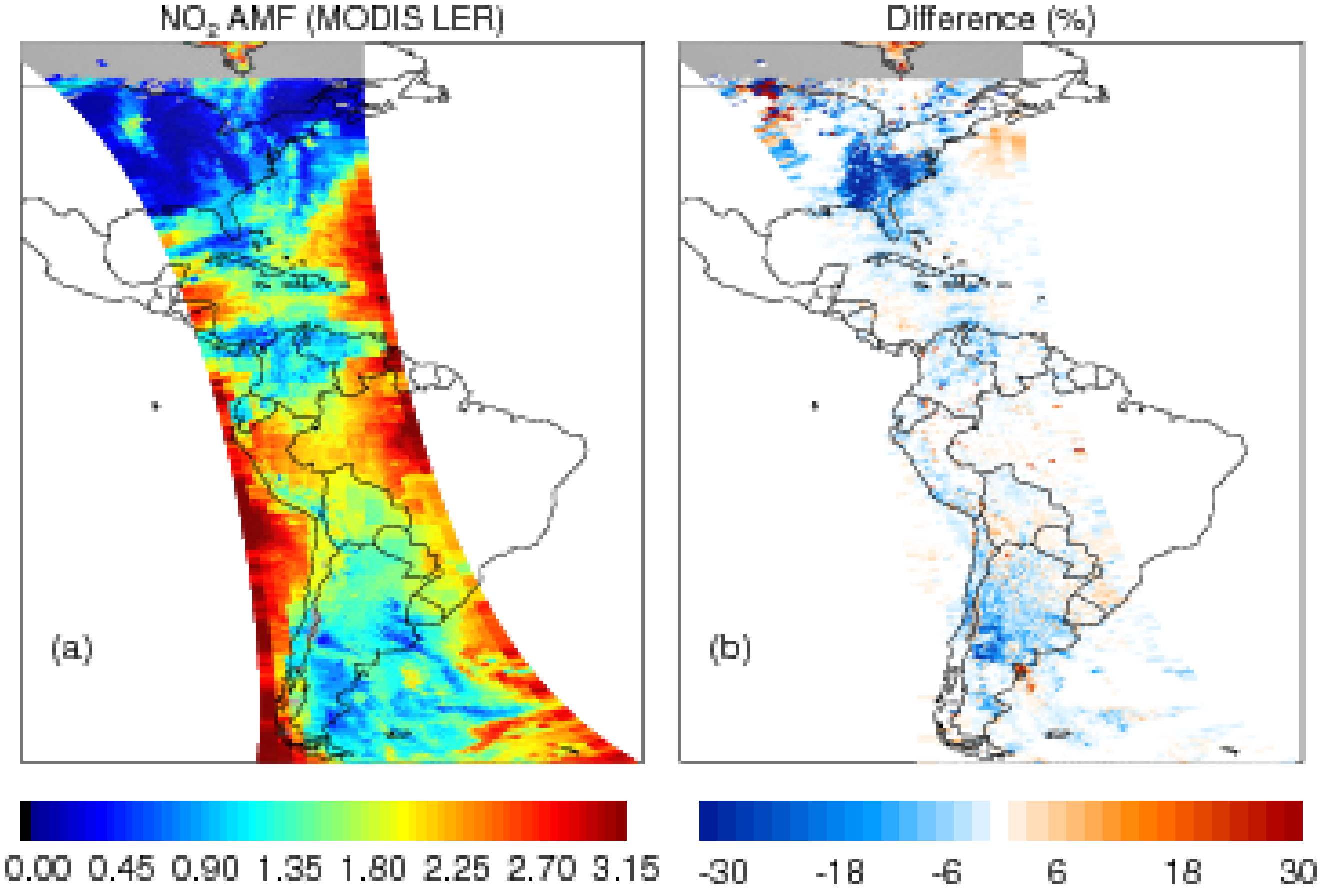


BRDF effects on OCP from O_2-O_2 are more pronounced than those from RRS.

OCP

Comparison of tropospheric Air Mass Factors (AMF)

- NO_2 columns are inversely proportional to AMF: VCD=SCD/AMF
- AMF depends on both surface LER and cloud parameters.

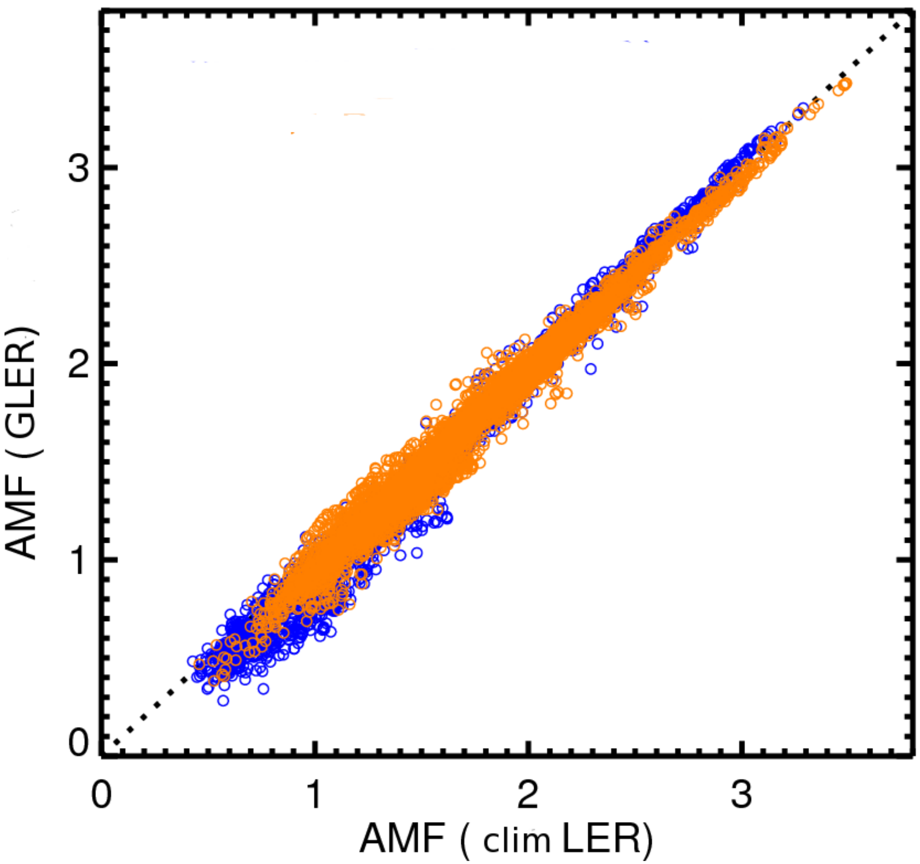


AMF differences are small over unpolluted and overcast areas. Over polluted areas, they can be up to 50%.

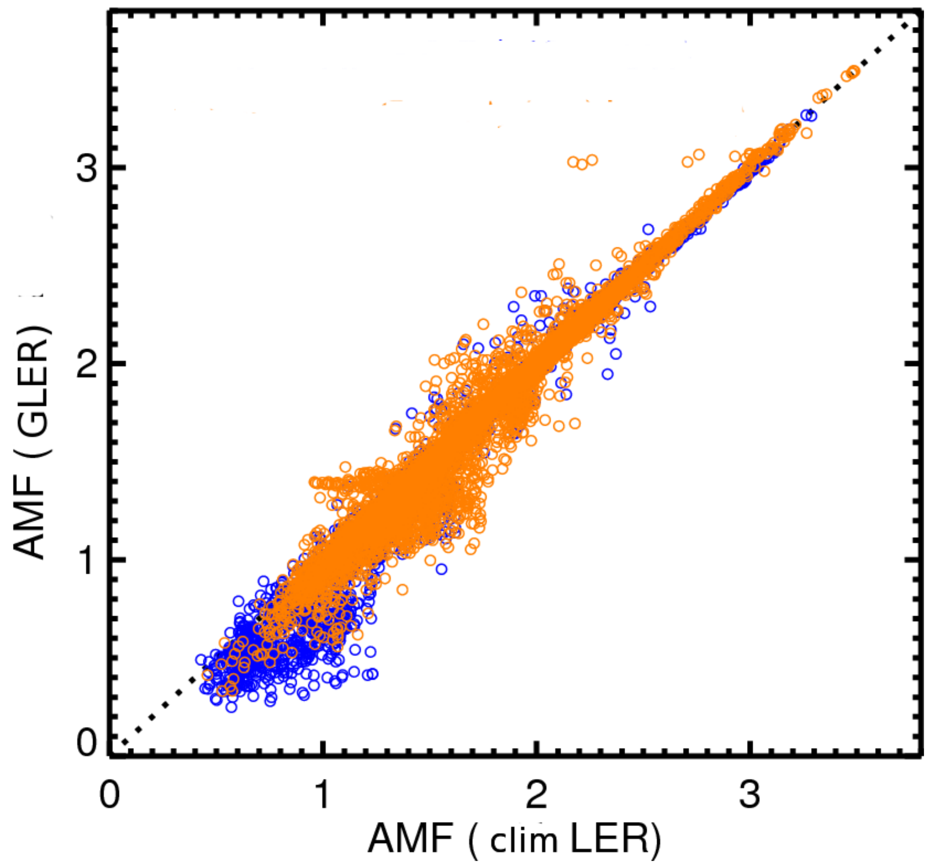
OMI orbit 12414 of Nov 14, 2006

Comparison of tropospheric AMFs, cont'd

Mostly clear scenes with ECF < 0.25
Ocean – orange; Land - blue



LER changes only, clouds unchanged:
AMF differences are from -30% to +7%



Both LER and cloud parameter changes:
larger AMF differences from -50% to 15%

Conclusions

- **Developed a new approach of accounting for BRDF effects on cloud and trace gas retrievals.**
  - **No major changes to existing algorithms are required.**
  - **Can be easily applied to current and future instruments.**
- **Comparisons of the standard cloud products with those derived with GLER**
  - **Mean ECF and OCP differences are small, however they can be substantial for individual pixels (up to ±0.05 for ECF and up to 100 hPa for OCP)**
  - **OCP differences are noticeably higher for O_2-O_2 than for RRS**
- **The use of GLER can increase the NO_2 vertical columns by up to 50% over polluted areas. Only minor changes within 5% are over unpolluted and overcast areas.**

Future Work

- **Add more wavelengths applicable to other algorithms (e.g. the aerosol algorithm)**
- **Accounting for a variable wind speed over the ocean and oceanic foam**
- **Treating snow/ice**
- **Including aerosols in computations**
- **Application to other instruments (e.g., TEMPO or other geostationary? TROPOMI?)**
- **Evaluation (difficult)**

More information can be found in

A. Vasilkov et al., Accounting for the effects of surface BRDF on satellite cloud and trace-gas retrievals: A new approach based on geometry-dependent Lambertian-equivalent reflectivity applied to OMI algorithms, *Atmos. Meas. Tech. Discuss.*, doi:10.5194/amt-2016-133, 2016.